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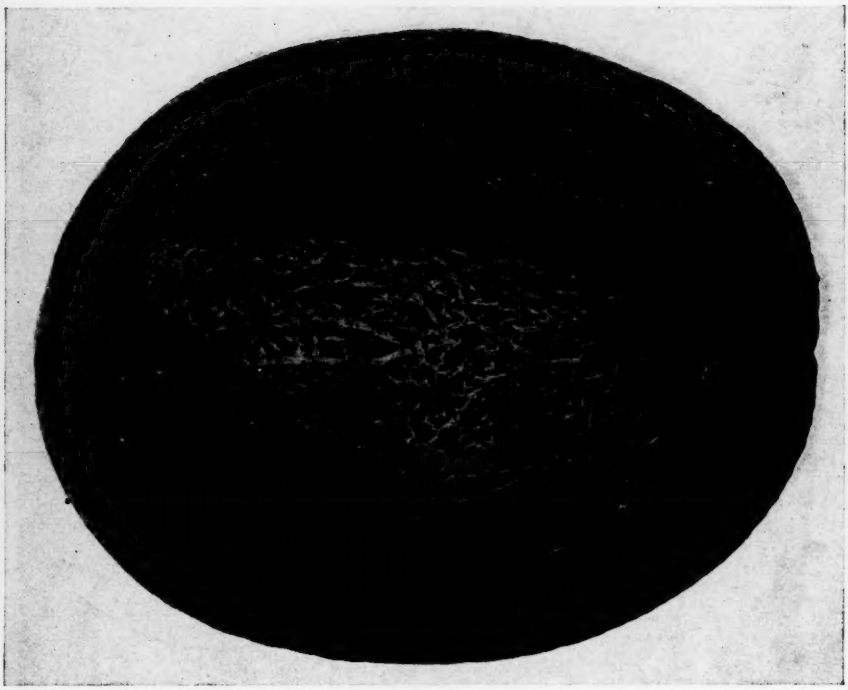

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Inherited "Epilepsy" in Cattle

Shortcuts for Grass Hybridizers

How Identical Triplets' Bones Grow

Halfwit's Sister Meets Half-Blindman

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The

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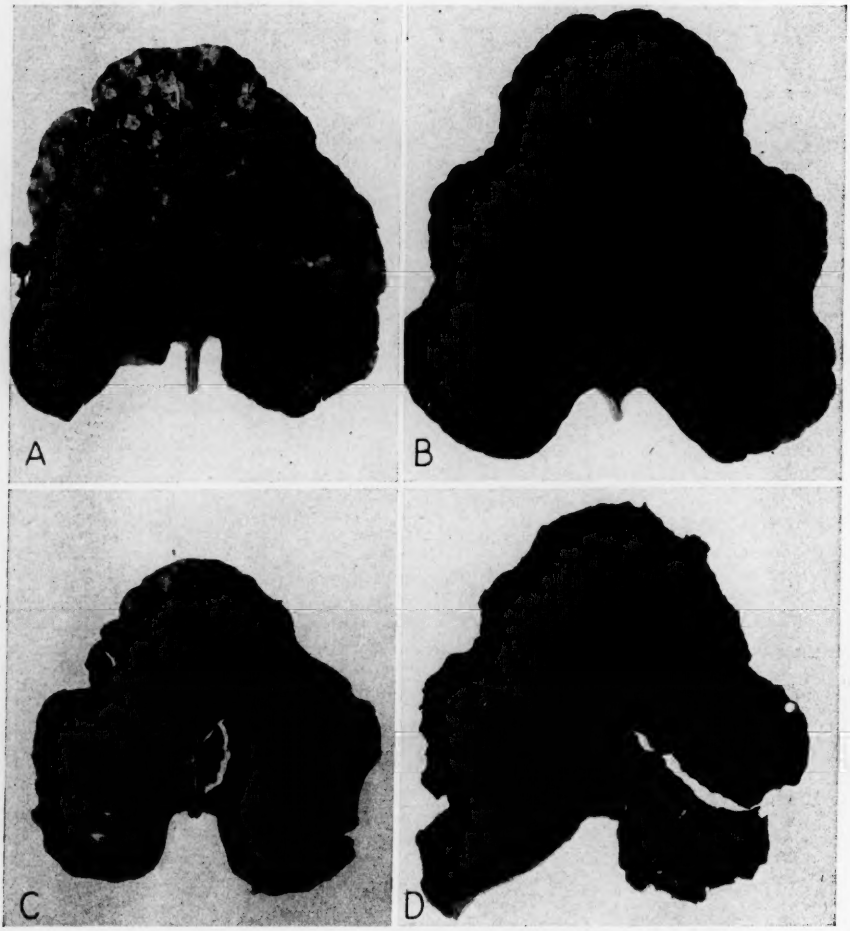


RESISTANT AND SUSCEPTIBLE STRAINS

Figure 1

These leaves show strikingly the differences in resistance to downy mildew and aphids encountered in this investigation. *A* is a leaf of the relatively resistant commercial variety, Green Flesh Rocky Dew. The plant was grown under conditions very favorable for the development of the disease and the infection is relatively mild. This may be compared in *B* with a leaf of a selected inbred strain of this variety which has greater resistance than the parent variety (*A*) from which it was derived. *C* shows a leaf of the aphid-susceptible commercial variety Seed Breeders grown adjacent to the aphid-resistant strain shown above (*B*). Several hundred aphids can be seen on this leaf. *D* is a dead leaf of the plant of the downy-mildew-susceptible Seed Breeders variety killed by the disease at a time when resistant strains such as that shown above (*B*) remained relatively healthy. Since it is difficult to control either of these diseases by spraying, or dusting, the importance of resistant varieties is obvious.

RESISTANCE OF CANTALOUPES TO DOWNY MILDEW AND THE MELON APHID

S. S. IVANOFF
Texas Agricultural Experiment Station
Substation 19, Winter Haven, Texas

IN many cantaloupe-growing sections of Texas, and in most localities in the United States, downy mildew and the melon aphid (*Aphis gossypii* Glover) represent two important hazards in the production of this crop. Downy mildew frequently destroys entire fields in a few days. In addition to the fact that mildew and aphids greatly lower the yield, cantaloupes from affected vines are low in sugar content and consequently unfit for the market. The control of these two pests by spraying or dusting is relatively difficult and expensive. The development of resistant varieties would make this crop easier and cheaper to grow, and would supply the consumer with higher quality fruit.

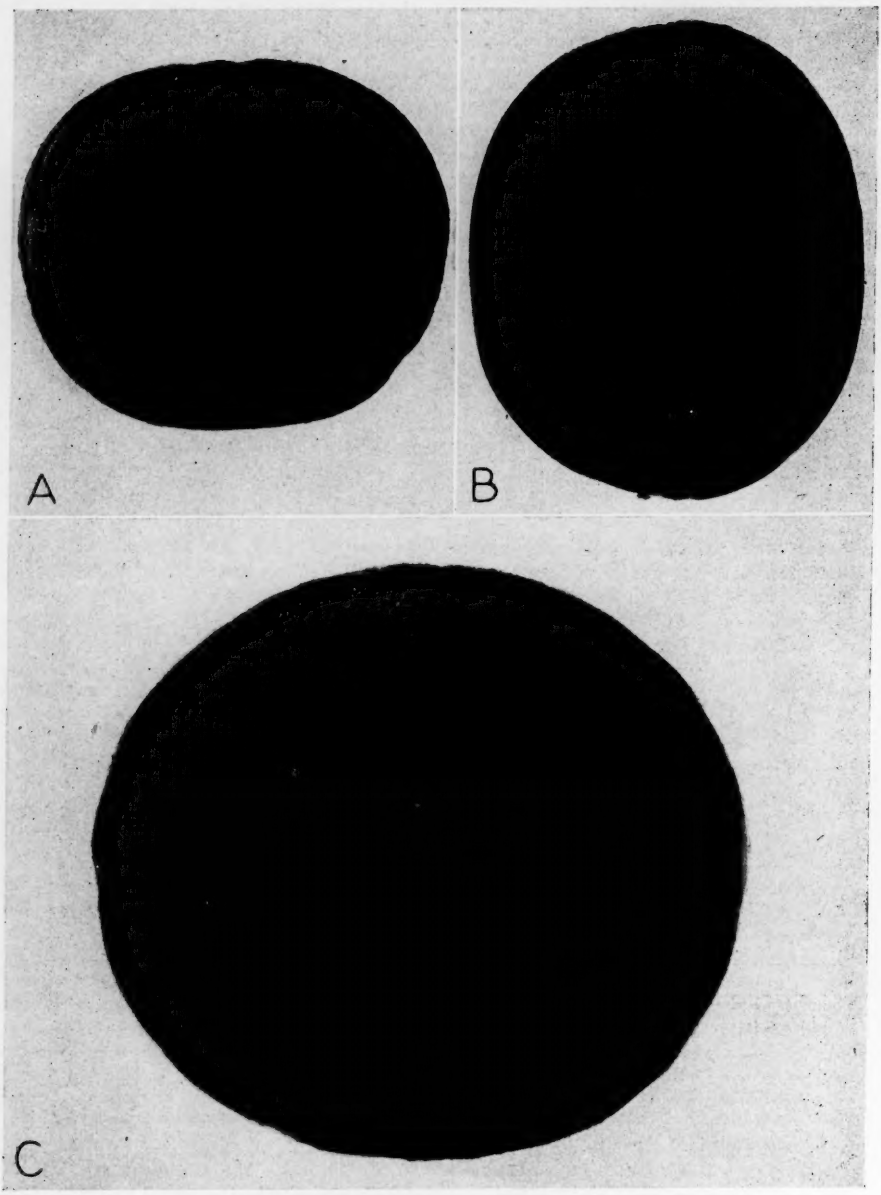
This article summarizes the progress made in the development of a shipping variety of cantaloupe of the Hale's Best type, resistant to downy mildew (caused by *Peronoplasmopara cubensis,* B & C, Clinton) and aphids (*Aphis gossypii* Glover) through the use of resistant varieties of West Indies origin. The aim has been to produce an early, prolific cantaloupe, yielding small, round, ribless, and well netted fruits; with small seed cavity and small blossom end; with thick, firm, salmon-colored flesh; and of sweet, spicy taste.

Sources of Breeding Material

Four varieties of cantaloupes, all of West Indies origin, have been found to be resistant to both downy mildew and aphids under Winter Haven conditions. They are Cuban Castillian (Melon de Castilla), Green Fleshed Rocky Dew (Kilgore's), Orange Fleshed Rocky Dew (Kilgore's), and Smith's Perfect (or Yellow Dew)*. These varieties, however, are not generally suitable for the shipping trade because of several of the following objections: soft rind, large size, lack of adequate netting, prominent ribs, tendency to crack, large seed cavity, large "button" (protuberance at blossom end), coarse or soft flesh, and lateness in maturity. Of the four varieties, Smith's Perfect approaches most closely the requirements of a shipping melon, and has been recommended as a commercial melon in Florida and in Puerto Rico.[1] The resistance of these varieties has been tested for four or more seasons at Winter Haven, Texas. The results thus far have shown that Smith's Perfect is the most resistant (both to downy mildew and aphids) of the four, with Green Fleshed Rocky Dew somewhat less resistant. With the exception of Cuban Castillian, these varieties make exceptionally strong vine growth. The leaves of these varieties have the common characteristics of being thick, hard, and upturned in a funnel-like fashion. The fruits of the Rocky Dew and Smith's Perfect varieties possess a strong musky flavor, and the sugar content may be very high. All are good yielders. None of these varieties, however, has been found immune to the downy mildew or aphids when the conditions for the development of these two troubles are favorable, but their resistance is high enough to make them good breeding material. All four are susceptible to powdery mildew.

Three commercial varieties were chosen as having the essential shipping and

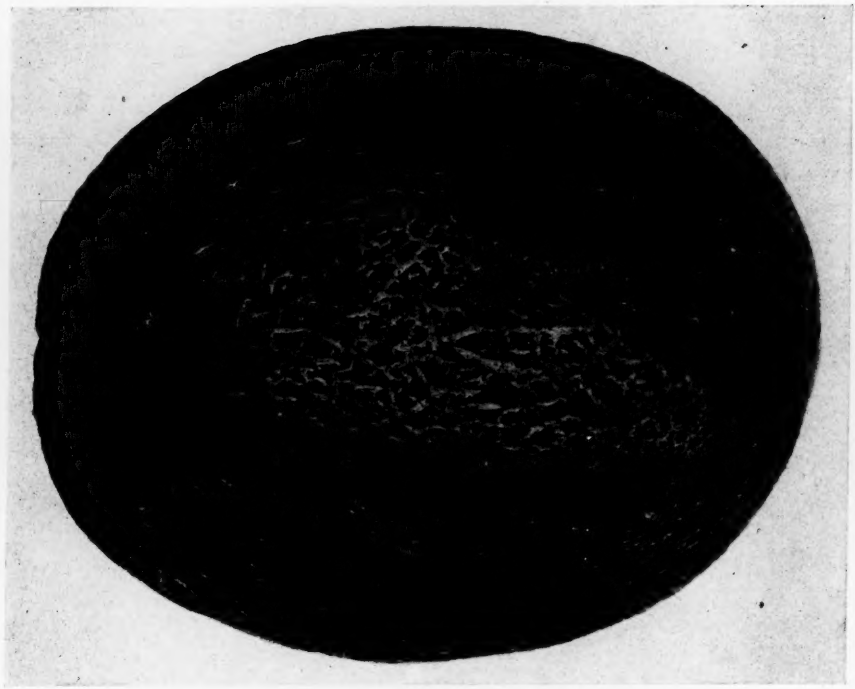
*Acknowledgment is made to Kilgore's Seed Company of Plant City, Florida, for seed supplied of all the four varieties, which have been originally introduced by that Company in the State of Florida.



FRUITS OF LINES RESISTANT TO DOWNY MILDEW AND APHIS

Figure 2

A—Small globose fruit with some netting, from a selected inbred line of the Green Fleshed Rocky Dew variety. *B*—Fruit of an inbred strain of the Cuban Castillian variety, one of the most resistant to downy mildew and aphids. This variety lacks the desired netting, firmness of rind and other qualities commercially desired. (Approximately 3/5 natural size.) *C*—A first-generation hybrid produced by crossing an inbred line of the resistant Green Flesh Rocky Dew with a selection of Powdery Mildew Resistant No. 45. This fruit has many of the qualities desired in a commercial variety: light salmon flesh, firm rind, desirable size and shape, and very good netting. It is also downy mildew and aphid resistant. By selection from such types, a strain has been produced in the fifth and sixth generations which combines all these essential characteristics in a uniform variety. (See Figure 3.)



RESISTANT F_5 GENERATION SELECTION

Figure 3

The fruit from the fifth generation of a line showing relatively high resistance to both downy mildew and to aphid infestation. This selection includes most of the qualities desired in a commercial variety. However, the heavy netting which is deemed a desirable characteristic (see Figure *2C*) has been sacrificed for other more essential qualities, particularly resistance to disease and good flavor. (Approximately natural size.)

commercial qualities lacking in the resistant varieties. These were Powdery Mildew Resistant No. 45, Seed Breeders, and Arizona Nugget, all three being of the Hale's Best or similar type. These varieties are good shippers, small in size, with small to medium seed cavity, small buttons, and fine netting. They are all very susceptible to downy mildew and aphids. Their fruit flavor may be sweet, but lacks the spiciness of some of the older varieties.

Increasing Resistance Within Resistant Varieties by Inbreeding and Selection

Since none of the resistant varieties was found immune to the attack of the downy mildew fungus or to aphids, when the conditions for the development of these two parasites were very favorable, efforts were made to obtain strains of greater resistance by inbreeding and continuous selection. Through this process, inbred strains of greater resistance and uniformity under local conditions were developed. Furthermore the inbreeding of the open-pollinated varieties also resulted in segregations which possessed some important horticultural characteristics later found useful in the breeding work. Inbred strains were secured which had not only a higher degree of resistance to the downy mildew but also yielded fruits of much smaller size,

with smaller cavities, better netting (in some cases), and in greater numbers per plant than the parent open-pollinated varieties (Figure 2*A-B*). It has also been noted in the progress of this work that as a rule the smaller the fruit size of a certain line the greater the number of fruits it is able to produce. Certain inbred lines have produced from six to 14 fruits per vine, of only 3.5 to 4.5 inches in diameter, while under the same conditions the commercial shipping varieties produced from two to four fruits per vine, of six inches or over in size. The fruits of the commercial varieties have been considered a bit too large for the requirements of the shipping trade. This particular characteristic of yielding smaller fruits but in greater numbers has been transmitted in part to the later hybrid generations.

Use was made, at the beginning of this work, of some inbred strains of Cuban Castillian obtained from Dr. G. F. Weber[2] of the Florida Agricultural Experiment Station, and also of a strain of Powdery Mildew Resistant No. 45, obtained from Dr. T. W. Whitaker of the United States Department of Agriculture.

The Appearance and Performance of F_1 Generations

Crosses made between resistant inbred strains and commercial susceptible varieties showed a degree of resistance to mildew and aphids somewhat intermediate between the two parents but approaching more closely the resistant parent in this respect. This partial dominance of resistance was measured by counting the numbers of mildew lesions and aphids per average leaf (the fifth leaf from the base of a branch) of the hybrid (Rocky Dew × Powdery Mildew Resistant 45) and of the two parent vines. In the case of the downy mildew, in one particular field test, the average number of mildew lesions for the hybrid leaf was six, while for the resistant and the susceptible parents the lesions were three and 22 per leaf, respectively. In the case of the aphids, in one greenhouse test, the average number of aphids (all stages) on hybrid leaves was 62; for the susceptible leaf, 433; and for the resistant leaf, four. Examples of resistance and susceptibility to downy mildew and aphids are shown in Figure 1*A-D*.

The netting of the F_1 fruit was satisfactory (Figure 2*C*) and approached that of the well-netted, susceptible parent. The size of the fruit, firmness of the rind, color of flesh, musky flavor, and size of the cavity were also intermediate between those of the two parents. The size of the button was intermediate but approached more closely that of the large buttoned resistant Rocky Dew parent.

In the F_2 and succeeding generations the usual segregation of characters was found to occur. Strains were isolated which carried the resistance of the resistant parent to full degree. No attempts have been made to study the ratio of resistance to susceptibility in the F_2 and subsequent generations, except in one case with a limited number of plants. Since the identification of degree of resistance is somewhat difficult, exact ratios of resistant to susceptible plants will be hard to obtain until a technique for uniform infection, relatively free from environmental influences, has been developed.

Resistance to downy mildew seems to be frequently associated with resistance to aphids, not only in the original varieties but also in most of the segregations of the F_2 and in subsequent generations. The mechanism whereby resistance is achieved is not known for either parasite. A point was made to note whether high resistance to downy mildew, to aphids or to both is associated with the leaf characteristics possessed in common by the four West Indies varieties. Thus far the upturned leaf characteristic has been found to be correlated, but not always associated, with resistance to both the downy mildew and aphids. This correlation has been a practical guide in making selections in seasons when the mildew and the aphids have not been present to a sufficiently high degree. However, lines resistant to disease and insects have been

secured which apparently do not have the outstanding morphological leaf characteristics of the resistant West Indies varieties.

Thus far strains in the F_4 to F_7 generations have been obtained which possess fairly firm rinds, fair to good netting, salmon-flesh color, desirable size and shape, sweet and slightly musky flavor, small cavity, small to medium-size button, and high yielding capacity. They have been tested for resistance under local experimental conditions and have performed satisfactorily in comparison to two of the most common varieties, Powdery Mildew Resistant No. 45 and Seed Breeders. In these tests the control varieties were entirely destroyed by downy mildew before ripening, while the resistant strains showed only a few mildew spots on the oldest leaves when the fruits were ripening. Likewise, the resistance of the new strains to aphid infestation has been striking in comparison to the check varieties. In two field tests the resistant strains had from none to a few aphids per leaf while the check varieties had from a few hundred to a few thousand aphids per leaf, with some vines destroyed altogether before the fruits began to net. A fruit from one of the resistant strains is shown in Figure 3. Further improvements of the breeding strains are in progress.

Since powdery mildew did not appear to any great extent when the early selections for resistance to the other two troubles were made, the new strains do not possess powdery mildew resistance to any appreciable degree. However, new crosses have been made with the aim to produce a melon resistant to both the powdery and the downy mildews as well as to aphids.

Summary

Four cantaloupe varieties of West Indies origin, Smith's Perfect, Green Fleshed Rocky Dew, Orange Fleshed Rocky Dew, and Cuban Castillian, have shown resistance to the downy mildew fungus, (*Peronoplasmopara cubensis* B & C Clinton) and to aphids (*Aphis gossypii* Glover) under South Texas conditions. Crosses have been made between these varieties and various other non-resistant commercial varieties in order to develop a shipping cantaloupe of the Hale's Best type resistant to both downy mildew and aphids.

Resistance to downy mildew and aphids appeared in the F_1 generation as partly dominant. Highly resistant lines, however, have been isolated in later generations which combined disease and insect resistance with shipping and other commercial qualities.

Literature Cited

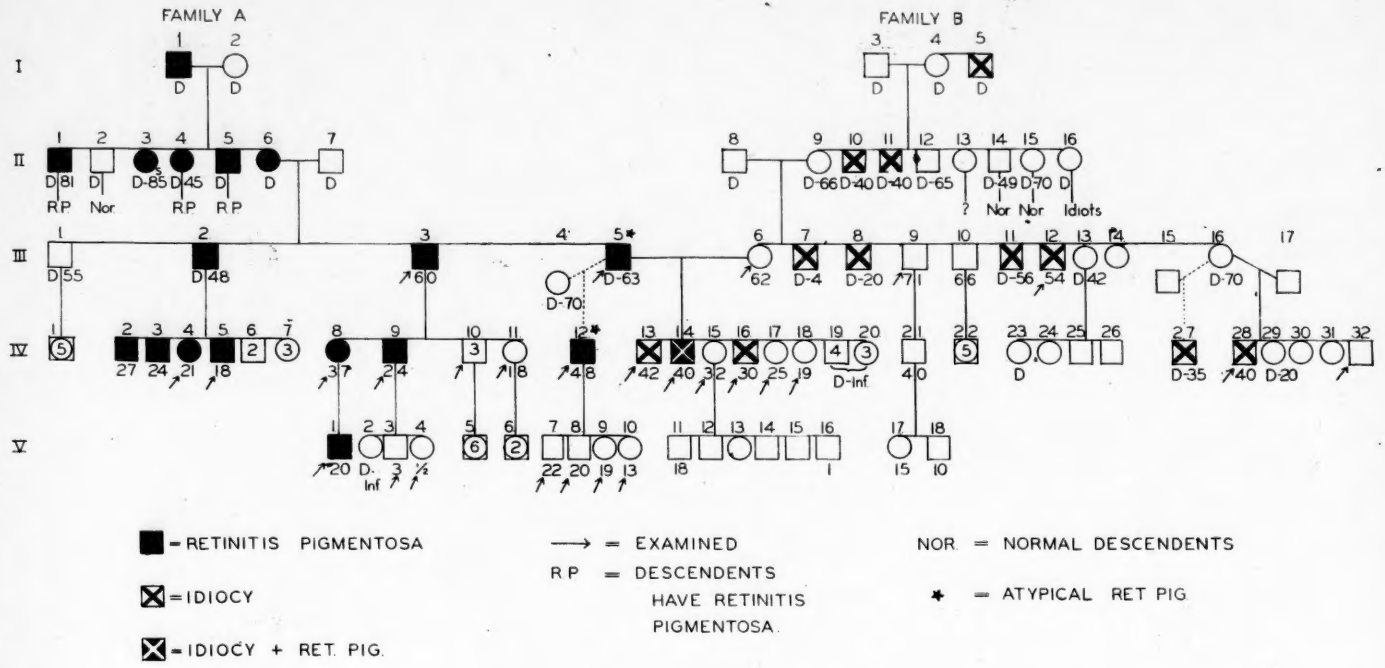
1. Riollano, Arturo. *Proc. Am. Soc. Hort. Sci.* 42:574. 1943.
2 Weber, G. F. *Fla. Agr. Exp. Sta. Ann. Rpt.*, p. 134. 1939.

◆

Hornlessness and Intersexuality in Goats

AN unusual example of how the fads of breeders and owners may work against livestock improvement is pointed out by Dr. S. A. Asdell of Cornell University (*Science*, Vol. 99, Pd. 124, Feb. 11, 1944). Reviewing the published data on intersexual goats, Asdell believes that the intersexes are all modified females. On this hypothesis, the data support the view that intersexually is due to a recessive gene which modifies female development, but does not affect male development.

Furthermore, Asdell finds, on the basis of his own observation, now totalling about 200 goats, that all the intersexual animals he has seen have been hornless. It thus appears that the gene for hornlessness is closely linked with the gene for intersexuality. The present tendency for goat breeders to select for hornlessness has therefore had the effect of increasing the frequency of the intersexual gene in these breeds and the number of intersexual individuals in herds. Thus in an unexpected way, breeding for a character assumed to be of economic importance has greatly intensified the frequency of an entirely distinct and most undesirable abnormality.



A PEDIGREE OF RETINITIS PIGMENTOSA AND IDIOCY

Figure 4

This pedigree shows a sibship which expresses two pathological genes, retinitis pigmentosa and a form of idiocy which is apparently sex-linked in inheritance. Possibly a genetic modifier of the pigment-gene is also involved.

RETINITIS PIGMENTOSA AND APPARENTLY SEX-LINKED IDIOCY

In a Single Sibship*

WILLIAM ALLAN† AND C. NASH HERNDON

THE pathological genes of man are sufficiently rare to warrant the reporting of any sibship in which two or more hereditary diseases are found. While investigating a family in which several members presented retinitis pigmentosa, it was found that an affected male had married into a family in which male idiots were frequent. This union resulted in the production of both blind and idiot offspring.

The accompanying pedigree (Figure 4) represents this sibship and the close relatives. Family *A* in this diagram is only a fragment of a large pedigree in which retinitis pigmentosa is evidently inherited as a dominant trait. In the entire pedigree there are 89 affected individuals, of whom 72 were living at the time of examination. In complete sibships of children of affected individuals there are 88 affected (46 male, 42 female) and 111 normal, omitting those who died in infancy.

The father of the sibship in question, III-5, died at age 63, but was examined prior to his last illness. His oldest son, IV-12, is illegitimate and presents retinitis pigmentosa. III-5 later married III-6, a member of Family *B*. In Family *B*, twenty-two male idiots have been observed in five generations. The full pedigree and the clinical features of the condition present in this family have recently been described elsewhere,[2] and only a part of the pedigree is reproduced in Figure 4. Idiocy is inherited in this family as an apparently sex-linked recessive trait, but the possibility of sex-limited dominant inheritance cannot be ruled out, as none of the affected males has reproduced. A search of the literature has failed to reveal a description of any similar family.

The union of III-5 and III-6 resulted in 13 pregnancies. Seven of these terminated in stillbirths or in children who died in infancy. No adequate cause for the heavy infant mortality in this sibship could be ascertained. Probable contributing factors were the rapid succession of pregnancies and poor hygienic conditions in the home. Of the six children who survived, all three of the sons (IV-13, 14, and 16) are idiots. They are completely helpless, being unable to walk or feed or cloth themselves, and speaking only gibberish. Both parents and the three daughters have normal mentality. The eyegrounds of all living members of this sibship were examined and the typical changes of retinitis pigmentosa were found in one of the idiot sons, IV-14. The three daughters are apparently normal, and the oldest, IV-15, has six normal children ranging in age from one year to 18 years, five of them sons.

Location of Gene for Idiocy

The genetic mechanisms of the two pathological hereditary factors present in this sibship are of interest. As has been pointed out,[2] the gene for idiocy may possibly be located on the unpaired portion of the X-chromosome, although this cannot be stated with certainty. It is well known that retinitis pigmentosa may be due to dominant, recessive or sex-linked recessive genes in different families.[1] It is apparent from Figure 4 that a dominant gene is inherited in Family *A*. Haldane[4] has shown, however, that dominant retinitis pigmentosa may be

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†Deceased April 24, 1943.

due to one of two genes, one being autosomal and one being partially sex-linked. From his analysis of pedigrees in the literature Haldane concluded that the responsible factor was autosomal in about 40 per cent of pedigrees and partially sex-linked in about 60 per cent. He estimated the cross-over value between the retinitis-factor and sex to be around 33 per cent.

Family *A*, then, was tested for partial sex-linkage. In the entire pedigree there are 16 critical sibships (sibships in which the father is affected and the sex of the affected paternal grandparent is known), yielding 64 normal and 35 affected individuals. These were tested according to the method given by Mather.[5] The frequency of recombination between the retinitis pigmentosa factor and the sex-determining portion of the X-chromosome was found to be 52.37%. If there is independent segregation we would expect 50% recombination; a value below 50% would suggest partial sex-linkage. The observed deviation of 2.37% from the expectancy for independent segregation is actually in the opposite direction from that which would be produced by linkage, and a deviation of this magnitude due to chance alone would be found in about seven out of ten samples of the size studied ($\chi^2 = 0.151$; Dev./S.E. $= 0.39$). The deviation, then, is entirely without statistical significance and there is no evidence that the factor responsible for retinitis pigmentosa in Family *A* is partially sex-linked. For the sibship in question, the most plausible hypothesis of genetic mechanism is that of an autosomal dominant factor for retinitis pigmentosa and a sex-linked recessive factor for idiocy.

Modified Eye Pathology

The eyeground findings in two members of this family provide a further point of interest. The father (III-V) of the central sibship and his oldest son (IV-12) both present an atypical arrangement of pigment in the fundus, while all other affected cognates examined present the characteristic changes. In typical retinitis pigmentosa the pigmentary changes are found principally around the equatorial region of the eye and consist of "characteristic jet-black accumulations of a spidery shape resembling bone-corpuscles"[3]; these clumps of pigment are small and quite numerous. IV-12 was found to present several large, oval, black, smooth-edged clumps of pigment, about half the size of the optic disk, lying close to blood vessels but not touching them. Two of these were present in the right eye and three in the left. No typical spidery clumps of pigment were observed, but numerous fine dust-like particles were scattered freely about the equatorial region. The retinal arteries were narrowed as in typical cases. The findings in the case of the father (III-5) were quite similar, but the idiot half-brother (IV-14) presented the typical arrangement of pigment. The 35 other affected relatives examined also presented typical spidery clumps of pigment in the fundi.

The symptoms presented by IV-12 and III-5 were also atypical. Night-blindness was not a feature of the disease, and diminution in visual acuity did not begin until after the age of 40 years. Loss of useful vision was complete in the case of III-5 by about the age of 50; vision at age 48 in the case of IV-12 was 20/60, and he complained of rapidly failing vision. In other affected members of this family night-blindness appeared at about 10 to 15 years of age, and useful vision was lost by about the age of 35 to 45 years.

Although the data are insufficient to warrant any definite conclusion, there is a possibility that a specific modifying factor might be present in certain members of this family which apparently has the effect of delaying the onset of the disease and modifying the grouping pattern of the pigment. Such a modifying gene might possibly have been introduced by II-7. The fact that one son (IV-14) of III-5 presents the typical form of the disease, while the other (IV-12) presents the atypical form like the father, would support this theory. The four children of IV-12 were normal on examination, but are too young to allow

the atypical form to be definitely excluded. The younger members of this family will be followed further to investigate the possibility of a modifying factor.

Summary

1. A sibship presenting independent segregation of retinitis pigmentosa and idiocy is described.

2. The most plausible hypothesis of genetic mechanism is that of an autosomal dominant factor for retinitis pigmentosa and a sex-linked recessive factor for idiocy.

3. Atypical eye-ground findings and symptomatology presented by two individuals with retinitis pigmentosa are described. The possibility that the atypical features might be due to a specific modifying factor is suggested.

Literature Cited

1. Allan, Wm. *Arch. Ophthal.* 18:938-947. Dec., 1937.
2. Allan, Wm., C. N. Herndon, and F. C. Dudley. *Am. J. Ment. Deficiency.* In press.
3. Duke-Elder, W. S. Text-Book of Ophthalmology. Vol. III, p. 2770. St. Louis, C. V. Mosby. 1941.
4. Haldane, J. B. S. *Ann. Eugenics* 7: 28-57. 1936.
5. Mather, K. The Measurement of Linkage in Heredity. Pp. 110-112. London, Methuen & Co. 1938.

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Planographed Texts

THE story goes that when Harvard University first established its excellent program of private radio broadcasts in the arts and sciences, a Harvard professor pictured before a sympathetic audience a novel plan to save America educationally. All that would be necessary would be to have the Harvard faculty lecture before the newly installed microphone and millions would sit by their receiving sets all over the United States to take notes. Added to the five-foot book shelf of books, here was a complete college education free. The Harvard audience naturally thought the idea to be altruistic and generous; and so it was. All went well until a Yale man heard about it. He saw in his mind's eye all the millions of radio Harvard men, all thinking in the same channels, all quoting the same Harvard authorities, all carrying green-bags, all wearing red ties, and all reverently breathing the magic word "Ha-vad."

Such a gruesome prospect was more than the sons of Eli could stand. From Yale the story went to Princeton, Columbia, Chicago, Caltech, and to all 48 of the Land Grant Colleges. Somehow our cultural Paul Revere, the original Yale man was able to stem the march of the red ties and the green bags, and the diversities of American college culture were preserved.

No matter how much or how little truth there may have been in this story, there are many college teachers who refuse to become regimented or standardized. They have not been swept off their feet by the excellent standard texts on the market. They have their individual methods of teaching, injecting into them somtehing of their own personality and rich research experience. They have their unique charts, diagrams, and references, and by means of these personal touches they make their subject a living inspiration to their students.

Unquestionably these individualistic points of view and methods of presentation have their advantage in a democracy where progress stems from a heterogeneity of human ideas and viewpoints.

Because big publishers will seldom take a chance on these new texts (on account of the excellence of books already established in the field), many of these texts are published in planograph by the authors primarily for their own students. One of these has recently appeared from Kansas,* where the corn

*Principles of Genetics, by Heman L. Ibsen of Kansas State College, 1942, Chicago.

grows tall and the livestock genes flourish.

The book is divided into nineteen chapters covering in an orthodox fashion the physical basis of heredity; mono-, di-, tri-, and polyhybrid ratios; Mendel, mendelism, and chromosomes; modified monohybrid ratios and lethal genes; modified polyhybrid ratios and epistasis; duplicate genes; multiple factors, modifiers; multiple allelomorphs; autosomal linkage; sex mutation other than gene mutation; mutation involving sections of chromosomes; selection; inbreeding and crossbreeding.

The text seems relatively free from errors, but one notices an apparent slip where one reads that crossing-over between the *X* and *Y* chromosomes does not take place in man, ignoring the work of recent years on incompletely sex-linked genes. The author seems to have avoided human material and human aplications in general, and it is unfortunate that photographic illustrations are lacking.

One feels that mathematical formulae have been purposely omitted in order to keep the presentation elementary. But this attempt makes it difficult for the reader to get a clear cut picture, for instance, of how populations of varieties based upon multiple factor differences are to be described and compared. Indeed, the chapter on quantitative characters is weakened in that it does not mention such relatively recent work as that of Castle and his students that "actually proved" the identity and additive nature of certain coat color genes in mice and rats and showed that they function as size factors as well as affecting coat color. Castle's early work is described where the results of an experiment in selection of hooded rats led to the formulation of a "multiple modifier" hypothesis. In that experiment the number of hypothesized factors could not be estimated and none of the actual factors could be isolated and identified.

In these days our educational programs have been so accelerated that college subjects are being introduced to high school and even to grammar school students. Simply written texts such as Ibsen's may come into their own as an elementary introduction to the subject of genetics, and they always serve (in the fashion mentioned above) as valuable collateral reading material for students using other texts.

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Genonomy

Taxonomy has been concerned with the description and delimitation of species and genera, based mainly on their comparative morphology. Carl Epling (*Science*, Dec. 10, 1943, p. 515) suggests the need for a new term: the study of "the relationships within these entities (taxonomic groupings) and the intraspecific structure which is conditioned by the ecology of reproduction. * * * Recent references to this endeavor as "the 'new' systematics, as biosystematics, and as population genetics, have not been generally accepted. Genonomy would embrace studies entailed by these relationships of individuals, such as their breeding structure, intra-specific variations and distribution, ploidy, the investigation of certain natural hybrids, and the relationship of the entities involved in the polyploids and hybrids."

INHERITANCE OF AN EPILEPTIC TYPE CHARACTER IN BROWN SWISS CATTLE*

F. W. Atkeson, Heman L. Ibsen, and Franklin Eldridge

A CONDITION similar in symptoms to epilepsy was first noticed in a purebred Brown Swiss bull about six months of age which had been purchased for a herd sire. The malady was characterized by the following symptoms: lowering of head, tongue chewing, slight foaming at the mouth and finally collapse in a coma. A veterinarian was called when the first attack occurred and the case was diagnosed as low blood calcium. After an intravenous injection of calcium gluconate the animal became normal again in from 15 to 30 minutes, but appeared listless for about 24 hours afterward. In subsequent attacks the same treatment was given with similar success. The attacks occurred at irregular intervals and were usually prompted by undue excitement.

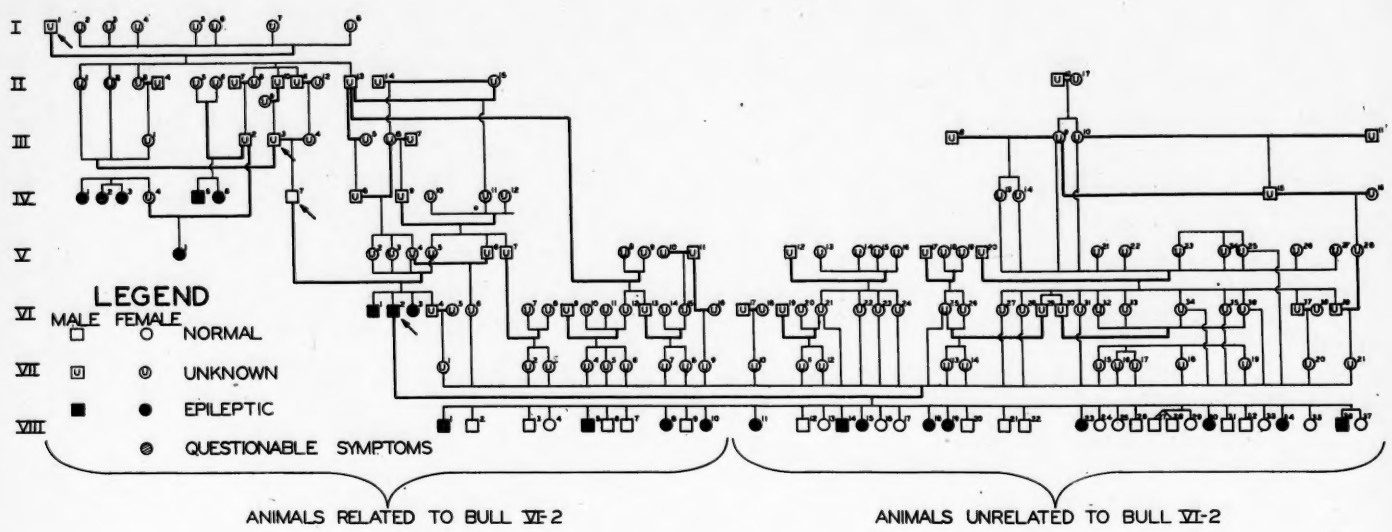
A number of this bull's progeny several months after they were born were noted exhibiting similar symptoms. These calves were given no medication or treatment of any kind, yet there were no fatalities and recovery from the attacks occurred in much the same time and manner as had the herd sire after injections of calcium gluconate. The appearance of the malady in the offspring of the affected bull suggested the possibility of hereditary transmission. Careful records were kept on all of his offspring in order to make a genetical analysis. In both the sire and the calves the attacks became less frequent with increasing age, and usually ceased when the animals were between one and two years of age. Later investigation of the offspring from ancestors of the bull indicated that some animals lacked some control of their hind legs throughout their life, often falling over for no apparent reason.

No reference in the literature has been found pertaining to the inheritance of epilepsy, or any similar malady, in cattle. White and Plaskett[5] in 1904 reported a somewhat similar condition in goats. These animals went into a rigid faint when frightened and could not jump fences. For that reason, the authors suggested the possibility of a new breed for these "nervous," "stiff-legged" or "fainting" goats. Lush[3] in 1930 found the same symptoms in another flock of goats. He stated that when frightened or startled the goats became rigid and while in this condition could be pushed over to the ground—"as if they were carved out of a single piece of wood"—. The spell lasted for 10 to 20 seconds, and after recovery the goats could not be frightened into another spell for 20 to 30 minutes. The mode of inheritance was not suggested. Somewhat similar symptoms were involved in the guinea pig affected with congenital palsy, as reported by Cole and Ibsen.[1] Lack of nervous control in varying degrees from inability to walk and inability to stand resulted from auditory stimuli. Severe spasms commonly lasted only a few moments. The authors concluded that the malady was inherited as a simple recessive and also was lethal in effect since none of the animals lived to reproduce. Snyder[4] in 1941 stated that in human epilepsy "the genetic factor has been considered less manifest and probably less important, although recent work with the electroencephalograph is opening up entirely new fields of research in the inheritance of this condition."

Mode of Inheritance

There were 37 progeny of the affected sire born during the period November, 1940 to March, 1942. Of the 19 females, nine were abnormal; and of the 18 males,

*Contribution No. 149 from the Department of Dairy Husbandry and No. 148 from the Department of Animal Husbandry, Kansas Agricultural Experiment Station.



GENEAOLOGY CHART OF "EPILEPTIC" BROWN SWISS CATTLE

Figure 5

The occurrence of an epileptic type of seizure in six generations of Brown Swiss cattle is charted here. The most likely hypothesis to account for this condition is that it is conditioned by a dominant mutation which occurred rather recently.

four were abnormal and one died at birth. The ratio of apparently normal to abnormal animals, therefore, was 10:9 among the females, 13:4 among the living males, and 23:13 for both sexes combined.

This ratio of 23:13 is not significantly different statistically from a 3:1, a 2:1 or 1:1 ratio. To postulate 3:1 or 2:1 ratios, however, would necessitate assuming the character to be recessive, and the bull VI-2 (Figure 5) to be homozygous, since he is epileptic. The gene frequency of the recessive gene in the dams should then be 25 per cent in the case of a 3:1 ratio, or 33 per cent if the ratio were 2:1. Since the epileptic condition has never been reported, either in any of the dams or elsewhere in the breed, such a high gene frequency would be highly improbable, making the assumption of a recessive mode of inheritance illogical. Finally, on the assumption of a 1:1 ratio, two possible interpretations of the mode of inheritance are possible: first, the character could be assumed to be recessive with the bull VI-2 homozygous and all the dams heterozygous; or second, the character could be assumed to be dominant with the bull VI-2 heterozygous and the dams homozygous recessives. The first assumption is ruled out because of the apparent absence of the character from the breed as a whole and from the known relatives of the dams. The interpretation that the epileptic character is inherited as a dominant is, therefore, the most logical, and since the ratio of the normal to the abnormal progeny of sire VI-2 is not significantly different from the expected 1:1 ratio, it is concluded that he is heterozygous for the character. Since a 1:1 ratio was obtained in both sexes, the gene must be autosomal.

Upon investigating the ancestry of bull VI-2 (Figure 5), who was the first animal in the herd found exhibiting this character, it was learned that his sire (IV-7) had been mated with three full sisters (V-2, V-3, and V-4) and produced three affected offspring (including VI-2). It was reported from memory that the other progeny of these three full sisters, or animals related to them, were not affected. This would indicate that the malady was transmitted through sire IV-7, since it seems improbable that each of the three full sisters was epileptic. There is no definite information, however, regarding whether or not any of his progeny from other dams showed any epileptic symptoms. The fact that his sire (bull III-3) was found to have two affected daughters (Nos. VI-1 and IV-3) and one granddaughter (No. V-1) extends the probable inheritance of the character back to sire III-3. Two other animals (Nos. IV-5 and IV-6) were also affected but showed no common ancestry with the other animals mentioned except that they all trace through two or three generations to bull I-1. Thus, there is a possibility that the character was transmitted by bull I-1 down through as many as five generations, but proof is lacking on animals farther back than bull III-3.

Although the ratio in the male offspring, 13 normals to four epileptics, does not show much resemblance to a 1:1 ratio, the deviation is not significant statistically. The numbers, however, are small, and there is still the possibility that additional data will show a true preponderance of normal males. It is known that the affected animals observed varied in the intensity of the attacks, in intervals between attacks and in predisposing conditions causing onset of an attack. Although careful observations were made, it is possible that some animals inherited the character but showed it so slightly or so seldom as to escape attention. This conjecture is supported by the study of epilepsy in humans by Lennox, Gibbs, and Gibbs.[2] They measured the electrical waves of the brain by means of an electroencephalograph, and showed that some individuals who apparently transmitted the disease gave a positive brain wave diagnosis even though they were negative with respect to the usual external symptoms. From this method of diagnosis, they suggested that cerebral disrhythmia, the essential manifestation of epilepsy, is inherited as a dominant.

No facilities were available for making brain-wave records of the calves studied but the deviation from a typical 1:1 ratio might have been caused by lack of accuracy in identifying all the affected animals. This also raises the question of safety in using unaffected animals for breeding purposes if they are progeny of affected animals.

The secretary of the Brown Swiss Cattle Breeders' Association of the United States of America stated that the animals represented in this report were, to his knowledge, the only animals of that breed affected with this malady. The fact that it has never been reported elsewhere, and is new to experienced breeders and dairy husbandmen supports the view that this is its only appearance. The striking symptoms of the malady, its inheritance as a dominant and the fact that all animals carrying the factor would ordinarily show it, suggests the possibility that the epileptic character is a comparatively recent autosomal mutation.

Discussion

Because of the nature of the symptoms of this malady all practical cattle breeders would be interested in keeping the character out of their own herds, and also in helping to prevent the dissemination of the factor throughout their chosen breed. Fortunately, from the standpoint of elimination, this character is inherited as a dominant and is expressed early in life. To free the herd or breed from this malady all affected animals should be eliminated. The only hazard in retaining, for breeding purposes, the animals not showing the character but being the progeny of affected animals is the matter of penetrance, as the degree to which the character is shown may be so slight as to be unnoticed but may be transmitted in the unmodified form.

Summary and Conclusions

1. A young bull which exhibited symptoms of epilepsy was mated to apparently normal cows and produced 37 offspring of which 23 were apparently normal, 13 were epileptic and one died at birth. Of the females, ten were normal and nine affected, while among the males 13 were normal, four affected and one died.

2. The deviation from an expected ratio of 1:1 was not statistically significant. The possibility that expression of the character might be influenced by sex or penetrance of the factor is suggested.

3. The character is inherited as an autosomal dominant, the evidence indicating that it is due to a recent mutation.

4. Elimination of the epileptic character from a herd or the breed can be accomplished by the elimination of all affected animals. Further check on apparently normal offspring from affected parents through observation of their progeny is suggested because of the possibility of penetrance, as to the degree to which the character is shown may vary. Reports obtained indicate that in affected animals the attacks occur less frequently as the animals become older, although some animals are apparently affected throughout life.

Literature Cited

1. Cole, Leon J., and Heman L. Ibsen. *Amer. Nat.* 54 (631):130-151. 1920.

2. Lennox, W. G., Erna L. Gibbs and F. A. Gibbs. *Amer. Med. Assn. Jour.* 113 (II): 1002-1003. 1939.

3. Lush, Jay L. *Jour. Hered.* 21(6): 242-247. 1930.

4. Snyder, L. H. Medical Genetics. Duke University Press, Durham, N. C. 130 p. 1941.

5. White, Geo. R., and Joseph Plaskett. *Amer. Vet. Rev.* 28:556-560. 1904.

THE BULK HYBRIDIZATION OF SMOOTH BROMEGRASS*

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THE improvement of many species of economically important plants has required that the breeder develop special technics for the production of controlled hybrids. This has been a problem with forage grasses. The great amount of labor involved in the hand method of emasculation and pollination has been a major "bottle-neck" in grass breeding programs. As a result, many attempts have been made to develop labor saving methods. The present paper has three objectives: (1) to review briefly the principal contributions that have been made to the technic of grass hybridization, (2) to present new findings on a method called bulk hybridization as determined from studies on smooth bromegrass (*Bromus inermis*) Leyss, and (3) to discuss the possibilities and limitations of this latter method in the light of present information.

Review of Literature

Jenkin[6] in 1924 described in detail the hand technic employed at Aberystwyth for the emasculation and pollination of grasses with forceps and camels-hair brush. Although time-consuming, his method is effective and highly dependable with flowers large enough for individual manipulation. A second method termed "continuous emasculation" was described by Jenkin[7] in 1931. It consisted of "picking off" the anthers as they extruded before the pollen had been shed, and was used successfully with *Phalaris* spp. whose flowers were too small for individual manipulation. Li *et al.*[13] reported the effective use of continuous emasculation on millet, *Setaria italica* (L.) Beauv., whose flowers were reported to be about one millimeter in length. Other short cuts described by Jenkin[7] were the hand pollination of unemasculated flowers, and the "mutual pollination" method in which the inflorescences of two species were bagged together. These last two methods depend upon a high degree of self sterility in the female parent.

Meulen[14] in 1933 reported successful emasculation of rice (*Oryza sativa* L.) with Kirk's suction method.[12] Vinogradova[20] in 1935 reported satisfactory hybridization of several relatively self-sterile pasture species by transfer of the male parent as severed culms, which were sustained in water under the isolator of the female parent. The method had previously been employed by Jenkins[9] on corn, and by Rosenquist[15] on wheat. When applied to grass it requires either hand emasculation or advance knowledge that the female parent is highly self-sterile. The reverse of this technic was reported by Keller[11] in 1943. He found that several species of forage grasses would mature viable seeds on culms that were detached from the parent plants prior to anthesis and sustained in tap water. The pollination of detached inflorescences has been used with sugar cane (*Saccharum officinarum* L.) since 1925. Verret *et al.*[18] reported that canes detached prior to flowering developed normally for several weeks if placed in a 0.05 per cent solution of sulfurous acid. More recent experimentation cited by Brandes and Sartoris[2] in 1936 has led to the use of a combination of sulfurous and phosphoric acids. They consider this method "a major contribution to the technique of sugar cane breeding."

Jenkin[8] again in 1937, described a

*Contribution of the Division of Forage Crops & Diseases, Bureau of Plant Industry, Soils and Agricultural Engineering, Agricultural Research Administration, U. S. Dept. of Agriculture, in cooperation with the Utah Agricultural Experiment Station and the Intermountain Forest & Range Experiment Station, U. S. Forest Service.

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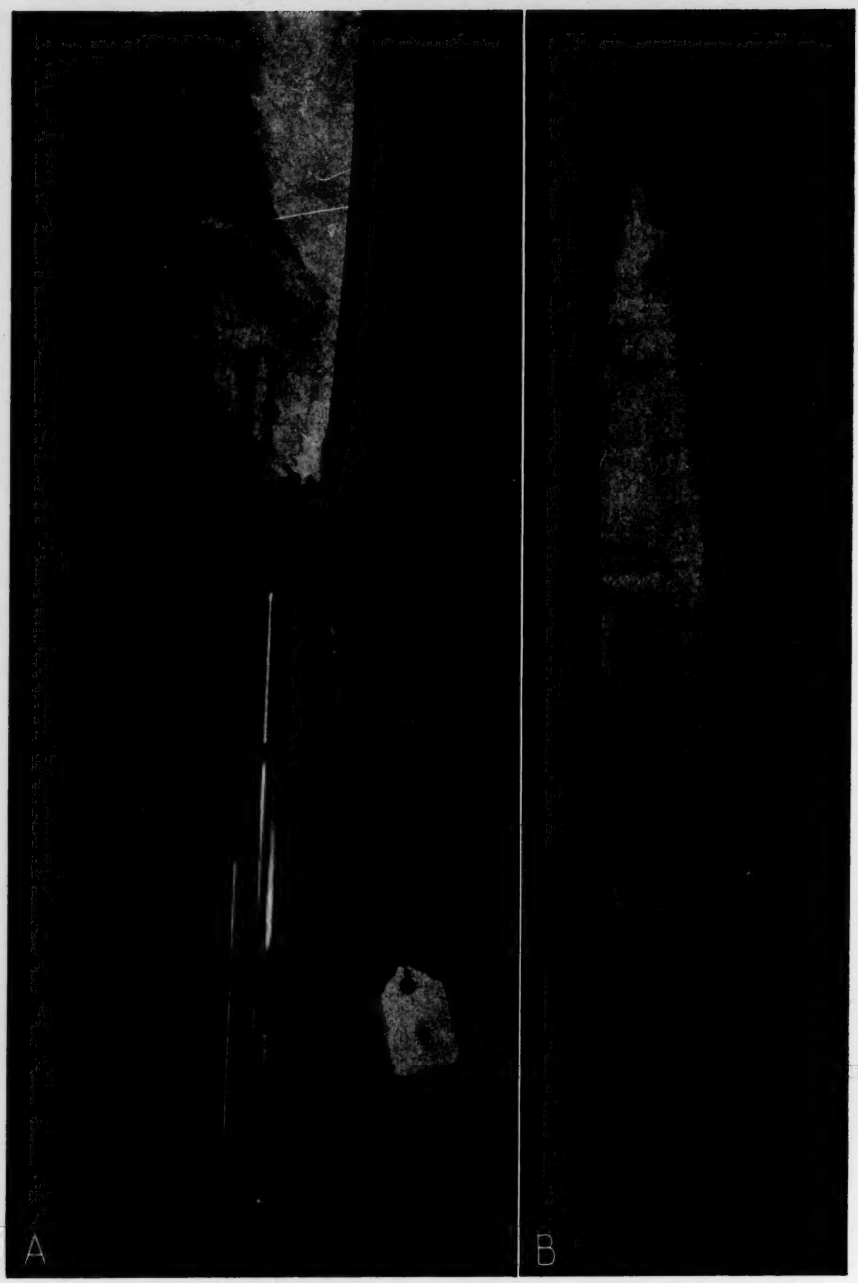

TECHNIQUE OF HYBRIDIZATION

Figure 6

A—Two panicles, emasculated by the hot-water method, have been bagged with a single selected panicle to supply pollen. This is sustained during anthesis by water in a vial attached to the wire stake with a rubber band. With no further attention, a fair setting of seed is obtained by this means. An intact culm is placed in a fold made to close the isolation bag. This prevents the bag from working up the wire. *B*—This shows the entire isolation bag as applied when self-pollination is practiced. The uncovered stake at the right shows position of the stake in the bag, with the loop at the top which holds the sides of the bag apart. Stakes are made of No. 9 galvanized wire, clips are Gem No. 1, and when rusty have a tighter grip.

method called "automatic pollination." It consisted of bagging together the desired parents, the female having been hand emasculated. The methods of Jenkin[6,7,8] were summarized and illustrated in 1938 by Beddows and Davis.[1] Vinall and Hein[19] in 1937 reviewed the methods of grass hybridization which had been successfully employed up to that time. Their discussion was largely restricted to the hand method of Jenkin[6] cited above, together with conveniences appended by others. Dolgusin[4] emasculated wheat and other cereals for intravarietal hybridization by "beheading" the spikelets. It is doubtful that this technic could be used successfully on forage grasses since their spikelets are usually very slender at the tip.

Stephens and Quinby[16] in 1933 published a brief account of the emasculation of sorghum (*Sorghum vulgare* Pers.) with hot water. They successfully demonstrated the principle that the female part of the flower would survive a higher temperature than the pollen. This contribution to the technic of bulk emasculation proved revolutionary. In 1935 Li *et al.*[13] reported an attempt to use hot water to emasculate millet, and in 1938 Jodon[10] reported its use on rice. Domingo[5] in 1941 reported extensive studies on the hot water emasculation of smooth bromegrass. He used inflorescences of comparatively self-fertile lines. They were immersed for five minutes in water. The panicles treated at 47° C. remained capable of seed production by wind pollination but were rather effectively emasculated, when judged by the production of selfed seed under bags. Domingo explored a number of rapid methods of controlled pollination, employing highly self-sterile plants as females. A modification of the mutual pollination technic of Jenkin[7] was the only method that yielded a satisfactory number of hybrid seeds. Disappointingly low yields of seed were also obtained when he attempted the bulk pollination of heat emasculated inflorescences.

Clark[3] confirmed Domingo's findings. In addition, he showed that the proper treatment temperature varied with the time of day, presumably with air temperature. A treatment of 45° C. before 10 a.m. or after 5 p.m. was found to be as severe as a treatment of 47° C. during the warmest part of the day. At midday 49° C. might be satisfactory, but during the early morning or later afternoon this temperature would be fatal. Clark found that abundant wind pollinated seed was produced by unbagged inflorescences emasculated by temperatures which prevented the formation of nearly all selfed seed under bags. However, when paper bags were used in the controlled cross pollination of such inflorescences, little seed was obtained. Crested wheatgrass (*Agropyron cristatum* (L.) Gaertn and Western wheatgrass (*Agropyron smithii* Rydb) were treated in 47° C. and pollinated by the method of Vinogradova, i.e. pollen bearing spikes, sustained in water, were introduced into the isolation bag. The emasculated females yielded 14 and 22 per cent, respectively, as much seed as was obtained from similarly treated spikes that were exposed to wind pollination. Clark enclosed two pollen spikes in each bag along with four emasculated spikes. In another experiment, isolation bags were removed during the height of anthesis to allow wind pollination. The inflorescences were exposed for one hour on five successive pollen-shedding days. Only 25 to 30 per cent as much seed was obtained from these as from similarly treated inflorescences which were continuously exposed to wind pollination. Five daily exposures were considered ample to allow opportunity for pollination of a large fraction of the flowers. Clark's work, therefore, directed attention to the isolation bag and its effect on seed production.

Materials and Methods

A single clone of smooth bromegrass was used as the female parent. Previous limited bagging had shown it to be moderately self-fertile. Emasculation was effected by the use of Clark's modification of Domingo's technic. All controlled pollinations utilized another clone, known to be cross fertile with the fe-

male parent. Nineteen groups of panicles of the female parent were emasculated from the afternoon of June 18 to the forenoon of June 19, 1942. Each group contained 16 panicles which, after treatment, were divided into eight pairs. Three unemasculated pairs were added to each group of eight pairs that were emasculated. The treatments to which the eleven pairs were exposed are shown in Table I, and the results were determined by the relative numbers of seeds produced.

Isolation of panicles was effected by kraft paper bags 3" x 26" supported by wire stakes, as described by Domingo.[5] This technic has been in use at this station since 1937, and has proved highly satisfactory. All controlled pollinations were made by the method of Vinogradova.[20] Each vial of water sustaining the pollen parent was attached to the wire stake that supported the isolation bag. This was accomplished by a No. 20 rubber band and a short piece of wire.* The technic is illustrated in Figure 6. The pollen parent for each isolation bag consisted of a single panicle. This panicle was selected with great care in an effort to choose one that would flower simultaneously with the two panicles of the emasculated female.

Experimental Results

Comparison of Methods of Pollination

In Table I the seed yields from the eleven treatments are grouped into classes according to method of pollination. Two of these classes are further divided to allow comparison of yields from emasculated and normal panicles. The data represent all treatments from 44° C. to 49° C. inclusive. Emasculation reduced the production of selfed seeds to one-seventh. It is a fair assumption that not more than one seed in twenty, obtained by controlled hybridization of emasculated panicles, is a product of selfing. Likewise, not more than one seed in sixty, obtained by wind pollination of emasculated panicles, would be expected to result from selfing. It is probable that this latter ratio is even higher, because "self" pollen from these plants would have had competition from abundant pollen from other sources. The ratio of selfed to hybrid seed is also higher when a specific appropriate temperature is used, as will be shown later. It is clear that the time and duration of bagging, relative to the time of treatment and anthesis, is of little significance.

Wind pollination of emasculated panicles produced three times as much seed as controlled pollination under bags. Only one pollen panicle was enclosed in each isolation bag containing two emasculated panicles. The pollen panicle was placed in the bag prior to anthesis. Approximately 24 seeds were obtained per bag by these controlled crosses. The variation between bags ranged from 0 to 195 seeds. This wide range suggests that some pollen panicles placed in the bags did not flower simultaneously with the emasculated females. The use of two or more pollen panicles would have increased the chances of simultaneous flowering. The genetic factor in these studies has been eliminated by the use of clones. Therefore, the limitations of hybrid seed production under bags would seem to trace principally to pollination technic.

High seed yields obtained from some bags is good evidence that the isolation bag of itself is not a barrier to seed formation *during anthesis.*

The Limits of Satisfactory Treatment Temperatures

Panicles were emasculated at temperature ranging from 44° C to 49° C. Seeds resulting from three methods of pollination through this range of temperatures are reported in Table II. The data show that at the higher emasculation temperatures the set of selfed seed was less than the mean of one-seventh reported in Table I. Yields of seed from controlled hybridization differed little when temperatures of emasculation ranged from

*Recent greenhouse experience with smooth bromegrass has demonstrated that portions of the basal end of a culm provide a suitable substitute for wire.

44° C to 47° C. Treatment for emasculation at 49° C proved to be too severe. There was also a definite reduction in wind-pollinated seed when panicles were treated at 49° C. The emasculations at 49° were made between 10 and 11 a.m. and between 4 and 5 p.m. This temperature might be satisfactory from noon until 3 or 4 p.m. on a typical cloudless summer day when air temperatures are near the daily maximum, but for general use it is too high. The data indicate that temperatures as low as 44° gave good emasculation, but the results were somewhat inconsistent. Both Domingo and Clark, with more extensive populations, found 44° C too low to give reliable emasculation with five-minute immersions. Probably the most appropriate single temperature is to have the water at 47° C.

The data presented in Table III establish the existence of a daily cycle in the appropriate emasculation temperature, but the exact path of the cycle and the factors affecting it have not been worked out. It appears to follow a course related to that of air temperature. The assimilation of CO_2 throughout the day as measured continuously by Thomas and Hill[17] gives a somewhat similar cycle. The exact nature of the treatment-temperature cycle and factors affecting it merit further investigation.

Wind pollination of treated panicles represents their maximum potential productivity. Therefore, the principal comparisons should be between wind and self pollination. A trend toward more seeds, from all methods of pollination, as the emasculation temperature is decreased is apparent (Table III). Most of the treatments at 47° C or 48° C have given satisfactory results, except that before 9 a. m. 47° C seems too severe. Likewise, after 4 p. m. 48° C

TABLE I. Seed yields resulting from different methods of pollination, and times and durations of bagging, of emasculated and normal inflorescences of smooth bromegrass.

Treatment*	Number of spikelets	Seeds per spikelet	Relative seed yields
Self pollination under bags:			
(1) Emasculated; bagged immediately	1619	.03	
(2) Emasculated; bagged 24 hours later	2015	.02	1
(3) Not emasculated; regular self pollination	759	.16	7
Controlled cross pollination:			
(4) Emasculated; bagged immediately; cross pollinated in bag	2120	.49	
(5) Emasculated; bagged after 24 hours; cross pollinated in bag	1874	.43	21
Natural wind pollination:			
(6) Emasculated but not bagged	1835	1.29	
(7) Emasculated and then bagged for 24 hours only	2100	1.45	
(8) Emasculated and then bagged until start of anthesis	1966	1.33	59
(9) Emasculated; bagged 24 hrs. later; off at start of anthesis	1872	1.25	
(10) Natural development; neither emasculated nor bagged	2048	2.32	100
(11) Not emasculated, but bagged until start of anthesis	1046	2.15	

*Emasculation treatments were applied June 18 and 19, 1942, and anthesis commenced June 23, 1942.

TABLE II. Seeds per spikelet produced by three methods of pollination of smooth bromegrass emasculated by treating at different temperatures (centigrade) for five minutes.

Method of pollination*	Panicles unemasculated	Temperature of emasculation of treatment (°C) 44°	45°	46°	47°	48°	49°
Self pollination	.155	.024	.046	.057	.004	.016	.002
Controlled hybridization	...	.50	.76	.34	.51	.21	.06
Wind pollination	2.32	1.58	1.48	2.03	1.22	.96	.55

*For selfing each value represents 421 to 820 spikelets; for controlled hybridization 518 to 855 spikelets and for wind pollination 1044 to 1603 spikelets, except unemsculated which represents 2048 spikelets. Unemasculated panicles that were bagged until the beginning of anthesis yielded 2.15 seeds per spikelet.

appears to be too severe. These data suggest that the investigator will be required to choose emasculation temperatures which are most appropriate for his needs. If it is essential that selfed seeds be reduced to the absolute minimum, a higher emasculation temperature will be required. With emasculation at any effective temperature, fewer hybrid seeds can then be expected, regardless of the pollination technic.

Discussion

Good seed yields obtained by wind pollination following emasculation, indicate that distance isolation may be effectively employed in the production of controlled hybrids. Two principal advantages are apparent: (1) a minimum amount of work during the rushed pollination season and (2) a large quantity of hybrid seed can be obtained. The plant material can be established at the isolation locations early in the spring, or even in the fall before the hybrid seed is desired. Then during the pollinating season the female parents need only to be emasculated with hot water. Isolation will be especially effective if it is desired to pollinate several different female genotypes with the same male, as in diallel crossing among a selected group of plants. The isolation locations required need then be no more than there are different pollen parents. Effective pollination can be assured if the male parent is adequately represented and properly located. Most efficient use of the male parent would seem to result from placing it in a single row surrounding the females. This would seem to assure adequate opportunity for the pollination of a small plot regardless of wind direction during anthesis. Any number of different species could be handled at each isolation location. When more than one female genotype of a species is located at a given isolation, it is essential that emasculation be complete, in order to prevent crossing between the females. The amount of seed produced by the pollen parent, over and above its known self fertility, would provide a basis for determining the extent to which this crossing had occurred.

Most of the information available to date on bulk hybridization of forage grasses has been obtained from smooth bromegrass, although some work has been done with crested wheatgrass and Western wheatgrass. The behavior of the latter species is essentially identical to that of brome. The extent to which this technic may be applied to other grasses is not known. A. T. Chisholm, formerly of the Division of Forage Crops and Diseases, conducted investigations on bulk emasculation of range grasses at Woodward, Okla., in 1939. His data were not published before his death but a summary was distributed to staff members of the Division. They suggest that of 39 species tested, 24 could probably be successfully emasculated with hot water. The effective temperatures for treatment, mostly of 10-minute durations, ranged from 45° C for some species to 48.5° C for others. Presumably most pollen shedding grasses may be subjected to this technic with modification of temperatures under different environmental conditions. The duration of the treatment, placed at five minutes in all studies conducted at Logan, Utah, is arbitrary. For some types of work, a shorter treatment, possibly at a higher temperature, may prove adequate. Pro-

TABLE III. Seeds produced per spikelet by three methods of pollination (wind, controlled cross and controlled self) as influenced by temperature and time of day of emasculation treatment.*

Temp.	Method of pollination	Approximate time of treatment 8-9 a.m.	9-10 a.m.	10-11 a.m.	4-5 p.m.
49°	1. Wind	----	----	.46	.63
	2. Cross	----	----	.01	.11
	3. Self	----	----	.01	.00
48°	1. Wind	----	1.06	1.23	.60
	2. Cross	----	.20	.20	.24
	3. Self	----	.06	.00	.00
47°	1. Wind	.82	1.23	1.43	1.41
	2. Cross	.27	.23	.73	.79
	3. Self	----	.06	.00	.00
46°	1. Wind	1.80	2.55	1.75	1.63†
	2. Cross	.31	.43	.27	.44
	3. Self	.00	.10	.10	.01

*Each wind pollination value derived from 270 to 535 spikelets; each controlled cross value derived from 160 to 265 spikelets; each selfed value derived from 122 to 297 spikelets.
†Treatments in this cell were at 45.5° C.

longed experience may reveal that treatments longer than five minutes, possibly at lower temperatures, would give more consistent pollen control, or less injury to the female gametophyte.

The use of paper bags to effect isolation, especially if the emasculated panicles are pollinated by the method of Vinogradova,[20] seems to afford the greatest protection from undesired pollen. This method offers the further advantage of permitting the investigator to complete crosses which are decided upon just prior to anthesis. At present, with restricted travel, it is also an advantage to have all of the breeding work centered at the main experimental area. Distance and paper bag isolation are both efficient technics for grass hybridization, but each has one disadvantage. Distance isolation requires that plans be completed several months in advance of the pollination season, while bag isolation places a limitation on the amount of seed that can be obtained per unit of effort. These limitations are overcome, and a highly flexible system obtained, if both methods are employed simultaneously. Crosses not arranged sufficiently in advance to permit the establishment of the parent lines for distance isolation can be carried out under bags, wherever the female plants are located.

Occasions may arise when a large quantity of hybrid seed is needed and the parent plants are not growing under isolation. The desired results may then be obtained with some species by the pollination of detached inflorescences.[11] This will require temporary distance isolation and a self-sterile female. These two factors, together with the use of chemicals, have made this a valuable technic in sugarcane breeding.[2] If the female is not self-sterile, the method is at present only an interesting possibility. Experimental evidence is not yet at hand to demonstrate that viable seeds can be produced an culms detached prior to pollination and emasculated with hot water.

Summary

Controlled hybridization of some grasses can readily be effected, either by distance isolation or under bags, using hot water to emasculate female parents.

Distance isolation is especially adapted to the production of a large amount of hybrid seed, or when several female parent plants are to be pollinated by a single male. Its use involves a minimum of attention during the pollinating season.

Crosses made under paper bags afford a maximum of protection from foreign pollen. In addition the work can be centered at the experimental station, and it is possible to make any crosses which are decided upon prior to anthesis.

Wind pollination of smooth bromegrass, *Bromus inermis* Leyss., produced 2.32 seeds per spikelet. Over a wide range of emasculation temperatures wind pollination yielded 1.33 seeds per spikelet, and controlled hybridization .46 seeds per spikelet. Natural self fertility produced .16 seeds per spikelet and self fertility following emasculation .025 seeds per spikelet. Selfed seed was materially reduced at the best emasculation temperatures while the production of seed from wind pollination and controlled hybridization remained relatively high. The high seed yields from some bags clearly indicate that the isolation bag does not of itself interfere with seed production.

Treatments at 47° or 48° C for five minutes gave satisfactory emasculation during midday, when air temperatures were high. Before 9 a. m. and after 4 p. m. when air temperatures were considerably lower, best results were obtained with lower emasculation temperatures.

Literature Cited

1. Beddows, A. R., and A. C. Davis. *Herbage Rev.* 6:221-227. 1938.
2. Brandes, E. W., and G. B. Sartoris. *U. S. Dept. of Agr. Yearbook* 561-623. 1936.
3. Clark, John W. *Jour. Amer. Soc. Agron.* (In press.)
4. Dolgusin, D. A. Moscow, 1936. Summary in *Herbage Rev.* 6:182. 1938.
5. Domingo, Wayne E. *Jour. Amer. Soc. Agron.* 33:933-1002. 1941.
6. Jenkin, T. J. Welsh Pl. Br. Stat. Aberystwyth. *Bull. Ser. H.* No. 2, p. 18. 1924.
7. ————. *Imp. Bur. Plant Genet. Herbage Plants Bull.* No. 3, 5-34. 1931.

8. ————————. *Fourth International Grassland Congress, Report.* 54-60. 1937.
9. JENKINS, MERLE T. *Jour. Hered.* 14: 41-44. 1923.
10. JODON, N. E. *Jour. Amer. Soc. Agron.* 30:294-305. 1938.
11. KELLER, W5:..5fl. *Jour. Amer. Soc. Agron.* (In press.)
12. KIRK, L. E. *Sci. Agr.* 10:321-327. 1930.
13. LI, H. W., C. J. MENG, and LIU, T. N. *Jour. Amer. Soc. Agron.* 27:963-970. 1935.
14. MEULEN, J. G. J. VAN DER. *Landbouw* 8:(9) 585-607. 1933. Summary in *Biol. Abs.* entry 13047. 1935.
15. ROSENQUIST, C. E. *Jour. Amer. Soc. Agron.* 19:968-971. 1927.
16. STEPHENS, J. C., and J. R. QUINBY. *Jour. Amer. Soc. Agron.* 25:233-234. 1933.
17. THOMAS, M. D., and G. R. HILL. *Plant Physiol.* 12:285-307. 1937.
18. VERRET, J. A. *et al. Facts About Sugar* 20:638-640. 1925.
19. VINALL, H. N., and M. A. HEIN. *U. S. Dept. of Agr. Yearbook* 1032-1102. 1937.
20. VINOGRADOVA, N. M. Regional Exp. Sta. of Agron. *Bul. No. 7,* 3-28. 1935. Summary in *Herb. Abs.* 6:362-364. 1936.

A Genes-Eye View of Man

GRADUALLY, as they become increasingly acceptable to the society of scientific and social disciplines, genetics and its basic unit the gene are assuming their proper places in the scheme of things. The reviewer is in complete sympathy with Glass, who puts into practice the proposal that it is fitting to treat the biology of man from the standpoint of his genes. After all, genes have a great deal to do with determining that he will be a man in the first place and what kind of a man in the second.

In the words of the author, the aim of *Genes and the Man* is to "indicate a new outlook, not to present genetics, or cytology, or embryology, or physiology, or even a summary of all of them, but rather to describe the operation and interaction of those factors which make the physical man, insofar as we know them or can reason about them today." This aim is pursued with vigor and enthusiasm as the author follows man from the fertilized egg through intricacies of cell division, hereditary mechanisms, embryological development, growth, physiology, and final senescence.

An integration of man's biology on any basis is a task not easily accomplished. Although the logical basis for attempting it from the standpoint of genes is sound, actually doing it is made particularly difficult by the fact that there are great gaps in our knowledge of how hereditary units do their work. In spite of these difficulties, Glass has indicated a proper direction. In following it he sometimes, in the opinion of the reviewer, gets a bit off the main track, e.g., statistical methods in four pages, or a bit too technical, e.g., figure 54 on the hypothetical action of white alleles of Drosophila. Such things as these, however, are matters of judgment on which it perhaps would be difficult for any two people to agree completely. A more serious criticism is that for proper appreciation of many of the phases of man's biology the treatment requires so much background in chemistry and other sciences that one wonders whether it is a book for a beginner or for one who has already had extensive training in biology and wants merely to consolidate his knowledge. One has a feeling that in some respects it falls midway between these two levels.

The reader may be surprised not to find more on Man's evolution in this book. As Professor Glass points out to the reviewer, however, another volume of the series which includes *Genes and the Man* has been planned to deal with the question of man's evolution. The author feels this should have been indicated in his preface.

Genes and the Man is a stimulating book and one well worth reading by the biologist or by one who has some background in biology. As a reference for teachers and students of biology it will most certainly serve a valuable purpose. In addition it may well find place as a textbook for courses in human biology.

Stanford University G. W. BEADLE

**Genes and the Man,* by Bentley Glass. 386 pp. The Bureau of Publications, Teachers College, Columbia University, New York, 1943.

OSSIFICATION SEQUENCES IN IDENTICAL TRIPLETS

A Longitudinal Study of Resemblances and Differences in the Ossification Patterns of a Set of Monozygotic Triplets

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STUDIES of human uniovular twins, triplets, quadruplets and even quintuplets have often included roentgenograms of at least some of the skeletal structures.[1,2,4,5,6,9] The greater likenesses in the epiphyseal patterns of monozygotics is striking and very useful as a method of determining the monozygosity of multuplets. Buschke[1] presents a review of the literature containing roentgen studies of multiple births.

The obvious likeness in the appearance of the roentgenograms of the hands of uniovular twins, while of value as a diagnostic tool, in no way reveals the total picture of likeness or unlikeness in the developmental patterns and schedules of these twins. In other words, such x-ray films reveal the likeness of two individuals at the moment of x-raying, just as would a comparison of hair color, but little can be learned from them as to the similarity in the *sequence of appearance* of the ossification centers in the two children.

Serial x-rays, together with other serial biological data necessary to make such comparisons of the developmental patterns, have been collected at the Fels Research Institute during the past 14 years. This report will present some of the facts which have emerged from an analysis of this data.

The Present Study

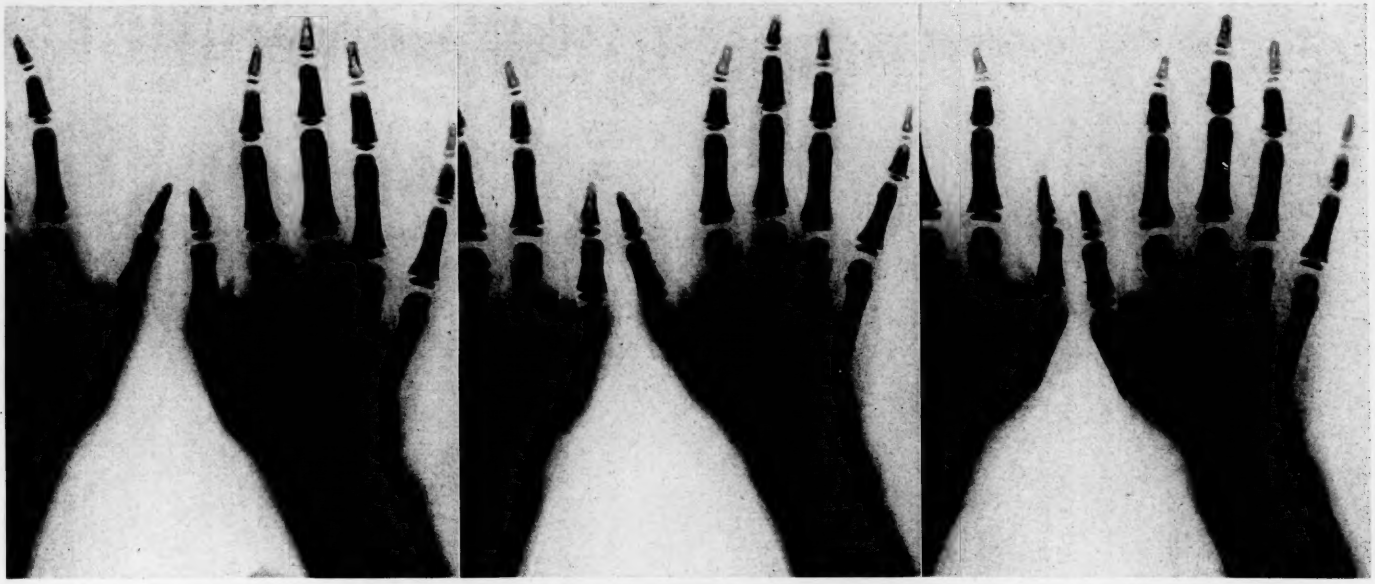
The present study is a comparison of the patterns of onset of ossification in a set of monozygotic triplets. Evidence for the monozygosity of these triplets has been presented by Sontag and Nelson,[12] following the plan of Siemens,[10] and by Pryor,[6] upon an examination of a set of x-ray films.

Figures 7, 8 and 9 show a roentgenogram and two photographs of the Kramer triplets. The similarity of these triplets with respect to the recognized criteria of monozygosity in multiple births is marked. The monozygosity of these triplets would not appear to be open to serious question. Their external environment has been apparently quite similar, and their illness history during the period covered by the present study, with the exception of two isolated colds, has been the same.

Roentgen films, taken at six-month intervals, are available on these three children, from the age of twenty-four months to fourteen and a half years. Differences between patterns of onset of ossification, as well as similarities, will be considered. The time of appearance of 26 ossification centers, selected on the basis of availability, are compared for the three subjects. Norms for these centers, as calculated for the onset time of the Fels series, together with individual values for each triplet, are presented in Table I. Methods of calculating time of appearance, and of establishing the Fels norms, have been presented by Pyle and Sontag.[7]

As seen in Table I, for each triplet the time of appearance of an ossification center was also transformed into a standard score. This operation makes easier the comparison of degree of likeness of onset patterns, since it expresses onset of all centers in equivalent terms. It provides a comparable scale for evaluating the onset patterns of those centers

*The authors wish to acknowledge the valuable contributions of Idell Pyle, Margaret Johnston, Mary Jane Pobst Reed and Janet Lipford in the collection and analysis of the data for this paper.



FRED HENRY JOHN

HANDS OF THE KRAMER TRIPLETS AT SEVEN YEARS, FIVE MONTHS

Figure 7

The general pattern of the bones is extremely similar. There are definite differences in the time at which ossification is initiated at various points in the hand structure. Consequently the triplets are definitely more alike at one stage of development than they are at another. Note the extra epiphysis at the base of metacarpal II, indicated by carets. All three triplets have this rare anomaly in both hands.

THE KRAMER TRIPLETS

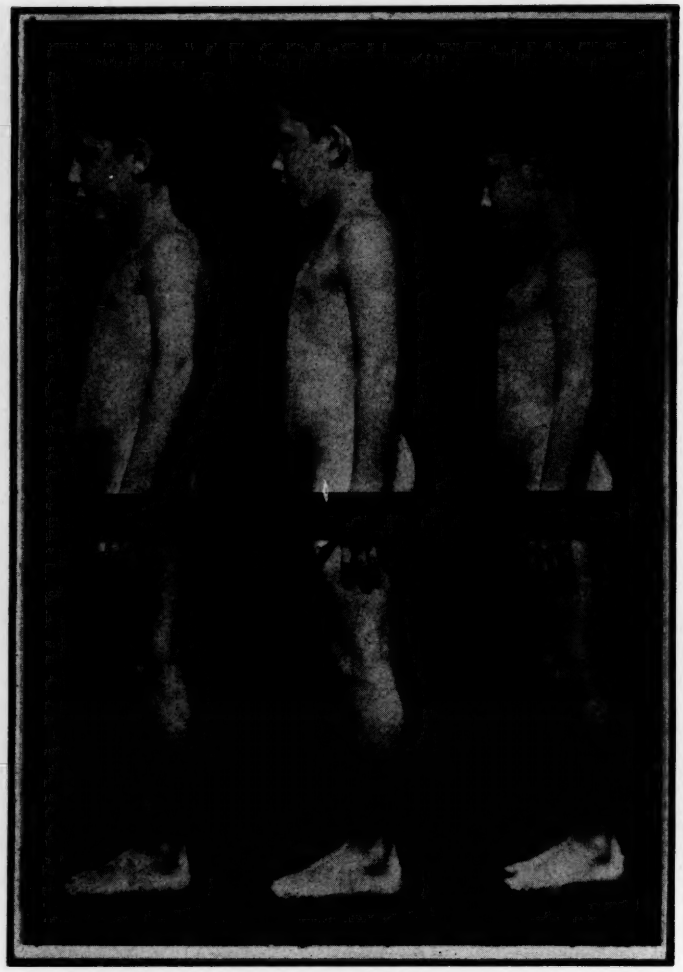
Figure 8

Fred, Henry, and John at an age of 13 years. That these boys are identical is established by their similar appearance and by a battery of other similarities. Their growth and the ossification pattern of their skeletons has been studied intensively from an age of two years to fourteen years, yielding a unique record of measurable and sometimes marked divergences in the general pattern of similarity in growth.

due to appear at an early age and those due to appear at a later age.

Expressing time of appearance in terms of standard scores* is necessary because one month's deviation in onset at one year of age is very different in significance from one month's deviation at six years, and because a deviation in appearance of a center whose appearance time varies little is of greater significance

*Standard Score $= \frac{X.-M.}{S.D.}$, where X is an individual raw score in a particular distribution, and M and $S.D.$ are the mean and standard deviation, respectively, of that distribution. See Lindquist,[3] pp. 129-134.



JOHN FRED HENRY

THE TRIPLETS AT NINE YEARS

Figure 9

The most striking difference between the three boys is in height. Numerous remarkable similarities in body conformation are revealed in these photographs.

than an identical time deviation of a center whose time of appearance in the group is very variable.

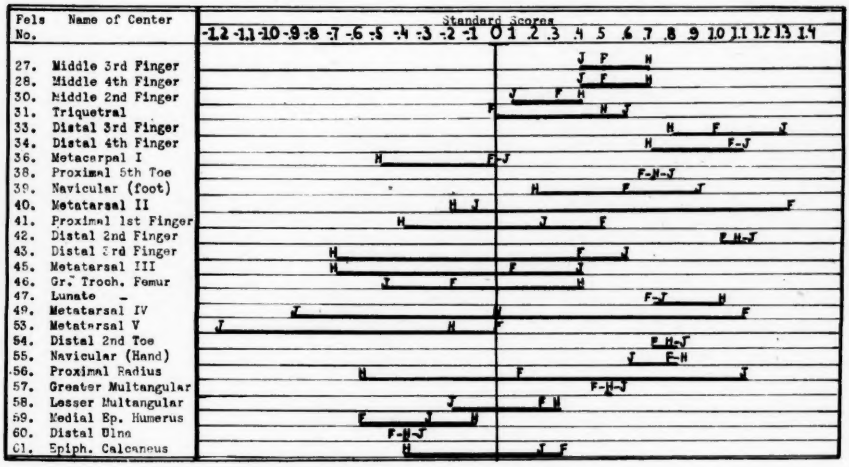
The analyses to be made are as follows:

(1) Comparisons of standard scores of the onset age for individual centers.

(2) Comparisons of means of standard scores at three different age-levels.

(3) Comparisons of the numbers of centers present at specific age levels.

Since this report will attempt to present likenesses and differences in developmental patterns of a set of uniovular triplets, it will in effect attempt to delineate at what point the genetic factor is


Fels No.
Name of Center
Standard Scores
-1.2 -1.1 -1.0 -.9 -.8 -.7 -.6 -.5 -.4 -.3 -.2 -.1 0 1 2 .3 .4 5 .6 7 .8 9 10 11 12 13 14
27. Middle 3rd Finger
28. Middle 4th Finger
30. Middle 2nd Finger
31. Triquetral
33. Distal 3rd Finger
34. Distal 4th Finger
36. Metacarpal I
38. Proximal 5th Toe
39. Navicular (foot)
40. Metatarsal II
41. Proximal 1st Finger
42. Distal 2nd Finger
43. Distal 3rd Finger
45. Metatarsal III
46. Gr. Troch. Femur
47. Lunate
49. Metatarsal IV
53. Metatarsal V
54. Distal 2nd Toe
55. Navicular (Hand)
56. Proximal Radius
57. Greater Multangular
58. Lesser Multangular
59. Medial Ep. Humerus
60. Distal Ulna
61. Epiph. Calcaneus

DISTRIBUTION OF OSSIFICATION

Figure 10

This chart shows the order and the difference in time of the ossification of the 26 centers studied recorded in this report. In respect to some centers there is a large difference in time of initial ossification, as in the case of Item 49. In others the triplets were simultaneous in their reactions, as in Item 38, 57, and 60. The items having a marked difference in time of onset are of particular interest because of identical genetic constitution of these three individuals.

superseded by an environmental factor as a determinant for certain aspects of the growth and development of these triplets.

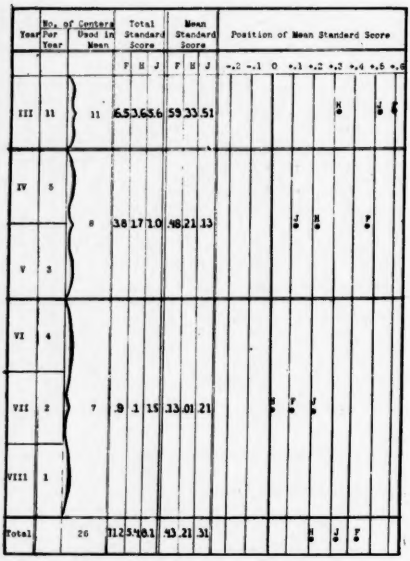
Comparisons of Standard Scores of the Onset Age for Individual Centers

Figure 10 presents graphically the information contained in the standard scores shown in Table I. It gives a picture of individual differences in onset of ossification. The horizontal distance between the individual values for each ossification center is an expression of the difference in time of onset of ossification for that center. For example, in Center No. 38, Proximal Fifth Toe, in which the time of onset for the triplets is the same, the points on the chart coincide; while in Center No. 49, Metatarsal IV, with onset ages at 41, 49 and 59 months, and standard scores of —.9, 0 and 1.1 for John, Henry and Fred, respectively, there is a correspondingly wide spacing between the individual values.

Fifteen of the 26 centers lie within a range of .5 standard score, for the difference in onset time between the fastest and slowest triplet. The other eleven centers range from .6 to 2.0 standard scores difference between fast and slow onset. The distribution is as follows: 0 — .3 standard scores, 10 centers; .4—.7 standard scores, 8 centers; .8 — 1.1 standard scores, 3 centers; 1.2 — 1.5 standard scores, 3 centers; 1.6 — 2.0 standard scores, 2 centers.*

The five centers with the least range of onset (0 to .1 standard score) were: Proximal Fifth Toe, Greater Multangular, Distal Ulna, Distal 2nd Finger and Distal 2nd Toe. The five centers with the greatest range of onset (1.2 to 2.0 standard scores) were: Metatarsal III, Metatarsal V, Metatarsal II, Proximal Radius and Metatarsal IV. This difference does not seem to be accounted

*The estimation of the appearance time of a center is subject to a certain degree of rating error, so that differences of .1, .2 or .3 sigma in the appearance of a center may not represent a real difference in onset time.


Year
No. of Centers Per Year
No. of Centers Used in Mean
Total Standard Score
Mean Standard Score
Position of Mean Standard Score
F H J
III 11 11 6.5 5.3 6.3 5.9 3.3 5.1
IV 5
V 3 8 3.8 1.7 1.0 4.8 2.1 1.3
VI 4
VII 2 7 .9 .1 1.5 3.3 .01 2.1
VIII 1
Total 26 11.2 5.4 9.1 4.3 2.1 3.1

DIFFERENCES IN INITIATING OSSIFICATION

Figure 11

This diagram shows the pooled relative standings in initiating ossification of those centers which are included within certain age-brackets. Henry was first in pooled scores in two of the intervals, and second in the other. Fred was second once and last twice.

for by any difference in the coefficients of variation, which average the same for each group. The predominance of the metatarsals in the centers whose onset times were most erratic is an interesting phenomenon.

It is evident, therefore, that although in most of the centers there is close agreement in time of onset for the triplets, in a considerable number there is a sizable span, ranging up to two standard scores, separating the earliest from the latest onset time of a particular center. For this reason, a diagnosis of monozygosity made at one particular time, employing only one set of films, might quite possibly give a somewhat less conclusive picture than a diagnosis made at some other time.

When the time of onset for each center is ranked as having occurred first, second or third for each triplet, the following sequences appear:

Name of Triplet	Onset Sequence 1st	2nd	3rd	Total No. Centers
Fred	8	13	5	26
Henry	13	7	6	26
John	12	8	6	26

Thus, in terms of onset sequence, as expressed by ranking the time of onset of each center, Henry and John show similarity, and both precede Fred.

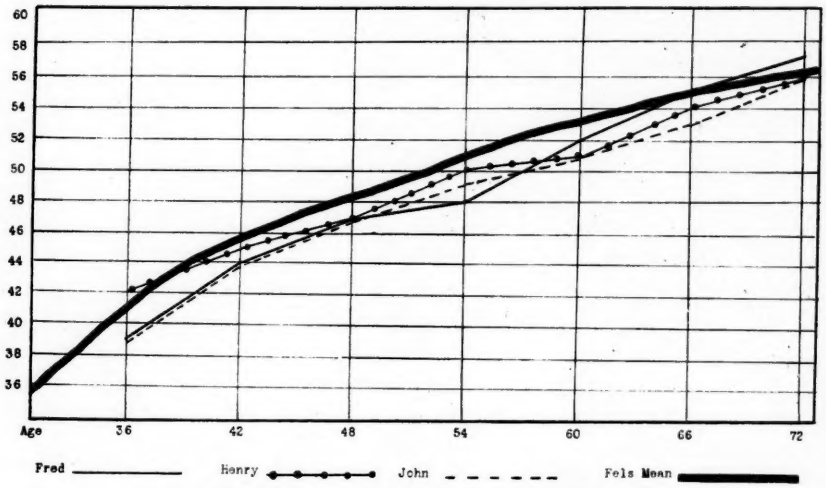
The sequence patterns of onset for the 26 centers show the following combinations:

Sequence Pattern	*No. of Times This Pattern Appears*
Fred—Henry—John	1
Fred—John—Henry	1
Henry—Fred—John	5
Henry—John—Fred	3
John—Fred—Henry	5
John—Henry—Fred	2
Henry—(Fred = John)	2
Fred—(Henry = John)	2
John—(Fred = Henry)	1
(Fred = John)—Henry	1
Fred = Henry = John	3
Total	26

Here again, in terms of onset sequence for individual centers, Henry and John are similarly advanced over Fred. Such distinctions, clearly discernible in a serial study of triplets, are much less noticeable when only one set of x-ray films is available.

When the 26 centers are grouped by anatomical areas, certain differentials in onset time appear. Henry tends to lead slightly in the onset of the two foot phalanges, the single metacarpal, the two tarsals and the four long-bone epiphyses. His lead is pronounced in the eight hand phalanges. However, in the five carpals, the position is reversed, with John or Fred leading in every instance. In the four metatarsals, John and Henry each holds two first places.

The tendency for Henry to lag in the onset time of the carpals is extremely interesting, and gives rise to speculation as to whether this is a chance occurrence, or whether some as yet unmeasured environmental factor, such as small differ-



THE TRIPLETS COMPARED WITH THE FELS MEAN

Figure 12

The time schedule of ossification of the triplets differs measurably from the mean at most points. Henry was ahead of the average for 36 months and led his two brothers until nearly five years of age. After that he fell behind.

ences in use, could account for such a phenomenon.

The above-described differences between the triplets should not be allowed to obscure the fact that, in spite of such differences, these monozygotic triplets are much more alike in sequence of appearance of centers than are ordinary siblings, who in turn are much more alike than non-siblings.[8,11]

Comparisons of Means of Standard Scores at Three Different Age Levels

The distribution of the standard scores as shown in Figure 10 can be sharpened by combining corresponding centers so as to derive a mean figure, thus presenting a less diffuse pattern.

Of the 26 centers available for the triplets, the number of centers due to appear within each yearly period, according to Fels Norms, are as follows:

Years of Age	*No. Centers*
Third	11
Fourth	5
Fifth	3
Sixth	4
Seventh	2
Eighth	1

The third year, with eleven centers due to appear, was treated as a unit; the fourth and fifth years, with eight centers, were combined; as were the sixth, seventh and eighth years, with seven centers. Plotted points, representing the mean standard scores for each triplet at each age level, are presented in Figure 11. The resemblances in mean onset time are striking. The distance in standard scores between the earliest mean and the latest mean, at the lower age level, is .26; at the middle age level, .37; and at the upper age level .20.

Henry and Fred present parallel developmental patterns, as indicated by the positions of their three means, with Henry the earlier. John is second in position at the lower age-level, first at the middle age-level, and third at the upper age-level. The mean onset time for the 26 centers combined, is Henry, .21; John, .31; Fred, .43.

It must again be emphasized that the differences mentioned above in no way should detract from an appreciation of the close parallelism of the triplets in mean onset pattern. The differences are

presented to show that, even in uniovular triplets, identicality of onset pattern is far from achieved.

Comparisons of the Numbers of Centers Present at Specific Age-Levels

Figure 12 presents graphically a comparison of the triplets with respect to the numbers of centers present at six-month intervals, from 36 through 72 months of age. At the 36-month level, Fred and John each have three fewer centers than Henry. At the 42-month level, this lead has been cut to a single center, while at the 48-month level the triplets have the same number of centers. At 54 months, Henry is again in the lead, one center ahead of John and two centers ahead of Fred. But from sixty months on, Fred takes the lead in numbers of centers present, and remains ahead through 72 months.

Table II presents these relationships in parallel columns. Here again, the essential similarity of the triplets is manifest, but again there are small differences. The change in leadership at sixty months, in which Fred passes Henry in numbers of centers present, is an interesting shift, and demonstrates again the uncertainty inherent in comparisons of skeletal relationships which are made on the basis of a single set of films.

Table I. Pyle norms (Pyle and Sontag [7], page 796) and individual values for the time of ossification of 26 centers, in the Kramer triplets.

Order Number of Center	Pyle Norms (Ages ± σ)	Individual Values: Months F.	H.	J.	Standard Scores: F.	H.	J.
27. Middle 3rd Finger	24.8 ± 7.6	29	30	28	.8	.7	.4
28. Middle 4th Finger	24.8 ± 7.6	29	30	28	.8	.7	.4
30. Middle 2nd Finger	26.9 ± 7.5	29	30	28	.3	.4	.1
31. Trimetrel	27.3 ±15.2	28	36	37	0	.8	.8
22a. Dist. 3rd Finger	27.8 ± 6.4	34	33	36	1.0	.8	1.3
24a. Dist. 4th Finger	28.3 ± 7.0	36	33	36	1.1	.7	1.1
26. Metacarpal I	29.8 ± 7.3	30	26	30	0	-.5	0
36. Prox. 5th Toe	32.0 ± 5.9	36	36	36	.7	.7	.7
29. Navicular (foot)	33.4 ±13.2	42	36	45	.6	.2	.9
40. Metatarsal II	32.4 ± 6.8	42	32	33	1.5	-.2	-.1
41. Prox. 1st Finger	34.8 ± 7.0	39	32	36	.6	-.4	.2
42. Dist. 2nd Finger	37.0 ± 7.9	45	40	46	1.0	1.1	1.1
23a. Dist. 5th Finger	37.4 ± 7.4	40	32	42	.4	-.7	.6
45. Metatarsal III	41.5 ± 7.9	42	36	45	.1	-.7	.4
46. Gt. Troch. Femur	42.6 ± 7.6	41	46	39	-.2	.4	-.5
47. Lunate	46.0 ± 19.3	60	65	60	.7	1.0	.7
48. Metatarsal IV	48.7 ± 9.0	59	49	41	1.1	0	-.9
50. Metatarsal V	53.6 ± 10.6	84	52	41	0	-.2	-1.2
54. Dist. 2nd Toe	57.0 ± 11.4	65	66	66	.7	.8	.8
56. Navicular (hand)	60.1 ± 14.1	72	71	69	.8	.8	.6
26a. Prox. radius	63.5 ± 17.2	66	84	82	.1	-.6	1.1
57. Gr. Multangular	64.3 ± 19.7	75	75	74	.5	.5	.5
58. Lesser Multangular	64.6 ± 15.2	67	69	61	.2	.3	-.2
59. Med. ep. humerus	73.6 ± 17.6	63	72	69	-.6	-.1	-.3
60. Distal ulna	82.4 ± 10.6	78	78	78	-.4	-.4	-.4
61. Epip. Calcaneus	89.6 ± 14.0	94	84	92	.3	-.4	.2

Table II. Number of centers present at six-months' intervals in the Kramer triplets.

Age in Months	No. of Centers: F.	H.	J.	Rank: F.	H.	J.
36	39	42	39	2.5	1	2.5
42	44	45	44	2.5	1	2.5
54	47	47	47	2	2	2
60	52	51	51	1	2.5	2.5
66	55	54	53	1	2	3
72	57	56	56	1	2.5	2.5

Summary

1. The patterns of onset of ossification of 26 centers in monozygotic triplets, although very similar, nevertheless show a number of differences.

2. The rates of skeletal progress of these triplets change so that their rank-order of onset of ossification centers is different at different ages.

3. The greatest variation of time of onset is in the appearance of the centers for the metatarsals.

4. The triplet who leads in onset time for the majority of the other centers, particularly in the hand phalanges, is later than his brothers in the onset time of all the carpals studied.

5. The triplet showing the least number of ossification centers present from 36 through 54 months, passes his brothers in this respect at 60 through 72 months of age.

Conclusion

It seems justifiable to conclude that certain environmental factors or acquired metabolic characteristics may be capable of modifying the genetic pattern of ossification.

Literature Cited

1. Buschke, Franz. Roentgenologische Skelettstudien an Menschlichen Zwillingen und Mehrlingen. G. Thieme, Leipzig. Pp. 47, 50 pl. 1934.

2. ———. *J. Hered.* 26:391-410. 1935.

3. Lindquist, E. F. A First Course in Statistics. Houghton Mifflin Co., Boston. Pp. 226. 1938.

4. Lund, S. E. T. *Hum. Biol.* 5:1-34. 1933.

5. Pryor, J. A. *Am. J. Anat.* 59:409-423. 1936.

6. ———. *J. Hered.* 30:249-255. 1939.

7. Pyle, Idell, and L. W. Sontag. *Am. J. Roentg. and Rad. Therapy* 49:795-798. 1943.

8. Reynolds, E. L. *Am. J. Phys. Anthr.* 1 (N.S.): 405-416. 1943.

9. Rigler, L. G. *Radiology* 30:461-470.

10. Siemens, H. W. *J. Hered.* 18:201. 1927.

11. Sontag, L. W., and Janet Lipford. *J. Pedia.* 23:391-409. 1943.

12. Sontag, L. W., and V. L. Nelson. *J. Hered.* 24:473-480. 1933.

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